

own, yet the mode of analysis adopted, and the conclusions arrived at, are as applicable here as elsewhere.

Building materials may be separated, for the purposes of classification, into the following groups:—1st, stone; 2nd, bricks; 3rd, limes; 4th, woods; 5th, metals. Under the head of bricks are included tiles, pottery, and artificial stones; under that of limes are included plaster, cement, sand, stucco, &c. These materials are to be examined, firstly, as to the nature and qualities of their constituent parts; secondly, as to the manner of their use.

1st. Stones.—The stones employed in building are grouped thus—1st, the argillaceous; 2nd, the calcareous; 3rd, the gypseous; 4th, the silicious; 5th, the volcanic and divers natures.

*The Argillaceous Stones.*—These are comprised of a base of alumina, generally combined with silicates and the oxides and sulphurets of iron. They do not effervesce with the acids, and are composed of successive layers, easily separated. The schists and slates are of this class.

The slates used in Paris are extracted at Angers, in the department of the Maine and Loire. The quarries are opened in a bed of silurian argillaceous schist of an enormous thickness, which outcrops for a length of ten miles, between Avrillé and Trelzé, passing under the town of Angers, where the Mayenne cuts the direction of the formation at right angles. There are eight quarries opened in a direction from east to west. Immediately under the vegetable soil is found a bed of incoherent schist, named in the country "cosse." This is followed by a bed difficult to cleave, and, therefore used locally as a rubble building stone; and lastly occurs, about 14 or 15 feet from the surface, the useful slate. It is worked in patches about 400 feet wide, leaving underneath an unknown thickness, though the depth quarried in many cases extends to 300 feet.

The quarries of Angers furnish a slate of a very fine grain, remarkably thin and light; although the specific gravity of the slate itself is very great. It is 3'000, water being 1'000, or 135 lbs. per foot cube. Four sizes are worked for the Paris market, viz.: the "grande carrée forte," 11½ long by 8½ wide, and ½ thick (0'298 x 0'217 x 0'003); 2nd, the "grande carrée fine," of the same dimensions as to length and breadth, but of about half the thickness; 3rd, the "cartelettes," 8½ long by 6½ wide by ½ thick (0'217 x 0'162 x 0'003); and 4th, the "cartelette fine," of about half the thickness. According to the statistical returns of the Ingénieurs des Mines, the value of the slates extracted at Angers in the year 1845, was at the pit's mouth 1,420,056 f. (56,400l.); and there were employed in the quarries 2,366 workmen.

The quarries of Charleville, in the department of the Ardennes, are worked upon a larger scale for the supply of slates for the east of France, Holland, and the Low Countries; but the expensive land carriage prevents their being employed in the capital. The value of their produce is about 1,793,945 f. (72,000l.); they employ 2,843 men. The slates are somewhat softer than those of Angers, consequently they decayed rapidly in the damp countries where they were usually employed. M. Viallet, Ingénieur des Ponts et Chaussées, overcame this objection by roasting the slates until they assumed a red tinge; their durability was doubled by this process. In the neighbourhood of St. Lô, in the department of Calvados, are some slate quarries in the Cambrian strata, which are used to a considerable extent in the neighbourhood, and which, if the land carriage were not so ruinous, would doubtlessly be formidable rivals to those of Angers. The cathedral of Bayeux is covered with the former; but even there, the price of the Angers slates is so much inferior to that of St. Lô, as to ensure the preference for general use, in spite of the superiority of the latter. The value of the slates extracted in the department of the Calvados in 1845 was 10,360 f. (414l.)

The usual practice in Paris and in the departments of the Lower Seine, is to nail the slates with two nails upon battens half an inch thick, and from ¼ inches to 7 inches wide, and to pay, either of deals cut in two, or of Some times these "voliges," as they

are called, are of poplar or sycamore, but they decay very rapidly. The slates lap over one another two-thirds of their length, leaving a "pureau" of one-third, when the inclination of the roof is not above 33°: at 45° the pureau is one-half of the slate; at 60° two-thirds. The battens are rarely laid close, for the slates are found to decay more rapidly if there be no circulation of air. The usual space between the battens is about 1½ inch. Hips, ridges, valleys, and gutters are executed as in England, with the trifling exception, that step-metal flashings are unknown; the slates are made good to the Pignon walls by merely covering the meeting angle with plaster.

*The Calcareous Stones.*—The formations which furnish the building stones of this class occur in the neighbourhood of Paris, and of the basin of the Lower Seine, in vast deposits. The ease with which they are extracted, and the proximity of the quarries to the places in which the stone is to be used, render their employ almost imperative; and it is to the use of these materials, that the monumental character of Paris is in a great measure to be attributed.

The nature of this class of stone is too generally known to render it worth while to dwell upon it at present. Our geological observations will therefore be merely confined to an enumeration of the great sources of supply. These are, for Paris itself, the vast tertiary formation, which nearly covers the whole of the departments of the Seine, Seine and Oise, Seine and Marne, l'Oise, and extends into those immediately around. Rouen, and some of the small towns above and below it, use large quantities of an indurated chalk met with on the banks of the Seine, whilst Havre and the intermediate towns derive their building stones principally from the oolitic formations of the department of Calvados.

Nearly the whole of the department of the Seine in which Paris is situated, may be considered as capable of furnishing calcareous stones for building purposes. The excavations which have been, and still continue to be, made, in and around Paris, are immense. About one-sixth of the town is built over the abandoned quarries, which are known under the name of the catacombs. The quarters St. Marcel, St. Jacques, St. Germain, and Chailot, are in this condition; and it is calculated that the mass of materials extracted thencefrom is not less than 385 million cubic feet. At present the bulk of the superior stones furnished by the department, comes from the quarries of Arceuil, Bagneux, Montrouge, and St. Cloud, which lie to the south-west of Paris.

The department of the Seine and Oise, is rich in quarries. Amongst them may be cited those of Saillancourt and Conflans, near Pontois, of Poissy, St. Nom, St. Maurice, l'Île Adam, and Chérence, near Mantes and upon the borders of the chalk. The department of the Oise furnishes the lias of Senlis, and the Vergélee of St. Leu. The Seine and Marne furnish the very beautiful stone called the Chateau Laudon.

This stone of the Chateau Laudon is the hardest, densest, and, consequently, heaviest, employed in Paris. It is nearly a pure carbonate of lime, containing in 1,000 parts 18 only of magnesia, and eighteen of silicate of alumina. Its colour is a grey, slightly tinged with yellow; it is subcrystalline, resists the action of the atmosphere, and bears a kind of polish. The quarries from which it is extracted are about 63 miles from Paris; yet, the great superiority of the stone causes it to be preferred wherever great solidity is desired. It was first employed in the erection of the bridge of Nemours; subsequently Rondelet used it for the paving of the Pantheon. The Barrière de l'Etoile is faced with it; the pedestals of the Pont d'Iéna, the large basins of the Chateau d'Eau, and of the fountain of the Innocents, and the parapets of the terre-plein of the Pont Neuf are executed of this stone, as are also the steps, parapet walls, and balustrades of the church of St. Vincent de Paul.

The specific gravity is 2'605; its weight about 163 lbs. Eng. to a foot cube; and it is able to resist a crushing weight of 332 kilo. per centimètre square.

The lias, which was formerly extracted to the south of Paris, was an excessively hard stone, but the quarries are nearly exhausted. The

name is still retained amongst the quarrymen, and is by them applied indiscriminately to the hardest beds of the *calcaire grossière*, which rarely occur in any great depth. At Arceuil, Bagneux, Montrouge, &c., the lias is fine grained and compact, but is rarely raised in blocks of more than a foot thick. At Montreuil it is occasionally 2 feet thick. At St. Cloud, it is soft; at Maisons, in the south-west of Paris, it takes a rose tint, and occurs in beds of from 9 to 10 inches thick. The specific gravity of the lias is, on the average, 2'439; the foot cube weighs 152 lbs.; the crushing weight per centimètre square is even greater than that of the Chateau Laudon; it is 445 kilog. It was doubtlessly for this reason that it was chosen for the execution of the columns of the exterior of the Madeleine and of the Bourse. The crown moulding of the large pediment of the Louvre is executed in lias, extracted at Mondon; it is of two pieces each 16 m. 24 c. long, by 2 m. 60 c. wide, by 46 c. high (53 feet 3 inches x 8 feet 6 inches x 1 foot 5 inches). The "cliquart" extracted at Vangirard and Mondon is a species of lias of a rather looser texture.

The stones called the "roches" are hard, of a coarse grain, very shelly. They occur in beds varying in thickness from 1 foot 4 inches to 2 feet 2 inches; their specific gravity is between 2'415 and 2'305, the heaviest being, as usual, the best. The foot cube weighs between 151 lbs. and 141 lbs.; the crushing weights 302 kilogs. and 293 k. p. e. square. The roche of St. Cloud is red and shelly, but of a very superior quality; it occurs in beds from 18 inches to 2 feet thick, and has the peculiar quality of being able to be employed on the wrong way of the bed. The isolated columns of the court of the Louvre and of the garden front of the Tuileries are of this stone, and have stood well for upwards of two hundred years. We shall have occasion to revert to this apparent anomaly on some future occasion. The basements of the Madeleine, St. Vincent de Paul, Notre Dame de Lorette, of the Palais du Quai d'Orsay, and of the Bourse, are executed in the "roche de Bagneux."

The bridges of Neuilly, the Pont d'Iéna, of Louis the 16th, and numerous similar constructions, are built of the "roche" of Saillancourt. At Rouen large quantities of the roche of Chérence are employed in works which require solidity: for instance, the stone bridge and the basement of the Custom House. The rubble filling of the bridge is, however, of the Vethuill stone, one of the lowest members of the tertiary formations. At Havre, the plinth of the Museum is executed in the Chérence stone. The practice of the French architects is never to employ the softer materials, such as the Caen oolite, near the ground.

The "pierre franche" is a fine, close-grained stone, less dense and hard than the "roche," but preferable for the decorative purposes of architecture, on account of the superior homogeneity of its grain. Its specific gravity is about 2'130; the foot cube weighs 133 lbs. nearly; the crushing weight is about 126 kilogs. per centimètre. The lower parts of the Pantheon are of this stone, extracted at Arceuil. The angle stones of the façade of the same building are executed in blocks from the banc royal of Conflans, of the same nature; they were 10 feet square by about 6 feet 6 inches high, and weighed about 24 tons. The arches of the portico and of the interior of the church and the dome, the entablature, and the capitals of the exterior order, are of the same stone. The Vergélee and the St. Leu are of the same category, as is also the stone of l'Île Adam; they are extensively used in Rouen and the neighbouring cities, on the banks of the Seine and the Oise, in those of the canal, and on the Northern Railway. The exterior dome of the Pantheon is in Vergélee stone.

The lambourde is a soft stone of an even, coarse grain; it decomposes when exposed to moisture, and is therefore only used in positions in which the action of the atmosphere is the slightest. The best stone of this description is extracted at St. Maurice, where it reaches 1 foot 8 inches in thickness. Some beautiful stones for internal works are obtained in this series at Conflans and at St. Leu, which attain 2 feet 2 inches thickness. The specific gravity varies between 1'897 and 1'709; the weight per foot cube is between 113 lbs. and 107 lbs.;

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174:18